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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04N

A2

(11) International Publication Number: WO 99/12332

(43) International Publication Date: 11 March 1999 (11.03.99)

(21) International Application Number: PCT/IB98/01280

(22) International Filing Date: 19 August 1998 (19.08.98)

(30) Priority Data:
9718326.3 30 August 1997 (30.08.97) GB

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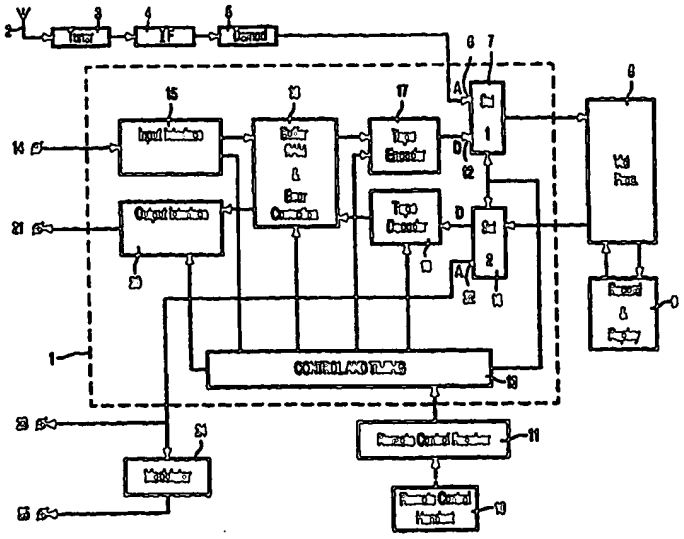
(81) Designated States: JP, KR, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: METHOD OF AND APPARATUS FOR RECORDING DIGITAL TELEVISION SIGNALS



(57) Abstract

A video recorder comprises an input (14) for receiving a digital television signal which is fed via an interface circuit (15) to a buffer RAM and error correction circuit (16). A control and timing circuit (13) passes this signal from the buffer RAM (16) to a tape encoder (17) which converts the code n-bits at a time into a 2" level code thus reducing the data rate by I/n. This reduces the data rate to one which can be recorded by a VHS recorder. On replay the inverse operation is carried out using the tape decoder (19), buffer RAM and error correction circuit (16) and output interface (20) to provide a replayed digital television signal at an output (21). A further embodiment includes a digital video encoder/decoder to enable analogue television signals to be recorded in digital form.

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DESCRIPTION

METHOD OF AND APPARATUS FOR RECORDING DIGITAL TELEVISION SIGNALS

The invention relates to a method of and apparatus for recording digital television signals. The invention further relates to a method of and apparatus for recording a plurality of television signals simultaneously.

In one particular aspect the invention relates to video recorders using components of standard analogue VHS recorders.

Currently much interest is being shown in and proposals have been made for digital television transmission both from terrestrial transmitters and for delivery by satellite. There are, however, still many analogue receivers and consequently the full introduction of digital television will take many years while the existing base of installed receivers is replaced. As a result there is a potential market for video recorders which can record and/or playback both analogue and digital television signals.

One proposal for a video recorder which can record and playback both analogue and digital television signals is disclosed in EP-A-0601963. In particular this document discloses a system for a video cassette recorder which is capable of recording/reproducing analogue video and audio signals as well as digital video and audio signals for a HDTV. The revolution of a head drum may be determined different from each other depending on the selected mode, i.e., digital or analog signal recording/reproducing mode, and thus the digital signal having a different recording bandwidth from the analog signal can be recorded on and reproduced from a conventional analog tape.

A further proposal published in US-A-5 335125 discloses a video tape recorder capable of recording a normal definition video signal and a high definition video signal having an image quality higher than the normal one in a simulcast for broadcasting an identical program in a conventional broadcasting system and a high definition system. The common video signal

is recorded in a conventional analog signal format at a tape feeding speed of the normal mode by an EP mode head defining a tracking width narrower than that of a standard mode head, while the high definition video signal is recorded in a digital form by a high definition video head additionally mounted on a rotary drum. Additionally, a common video signal recorded by a conventional video tape recorder can be reproduced.

Both of these prior proposals require the use of additional recording heads and/or different head drum speeds depending on the material being recorded or replayed. This increases the cost and complexity of the recorders.

It is an object of the invention to enable the provision of a method of recording digital television signals on a video recorder which conforms to the VHS standard. It is a further object of the invention to enable the provision of a video recorder which is capable of recording digital television signals using such a method.

The invention provides a method of recording a television signal in the form of a digital data stream on a magnetic tape using a video recorder, the method comprising the steps of;

- receiving the digital data stream
- converting the data to a multilevel code, at a data rate which falls within the bandwidth of the recording apparatus, and
- recording the multilevel code on the tape.

Digital television channels may typically have a data rate of 5Mbits/s, which is too high for recording on and replay from a standard VHS VCR. By converting the data into a multilevel code the effective data rate can be reduced. For example a four level code can encode two bits of data and thus divide the effective data rate by two. This then renders such a signal recordable as the data rate is reduced to 2.5 Mbits/s and this is recordable by a VHS recorder. It requires the provision of an encoder which will perform the conversion from a binary to quaternary code but such encoders can be readily constructed. It would also be possible to record digital television signals transmitted at an even higher data rate if more than four levels are provided, for example eight levels would enable three bits to be encoded for each data

period while a sixteen level code would allow four bits to be similarly encoded.

It has been disclosed in UK Patent Application No. 9605614.8 (PHB 34056) that teletext data multiplexed with an analogue television signal may be recorded on a VHS video recorder by encoding teletext data into a multilevel code, in a particular embodiment into a four level code, and thus reducing the teletext data rate to one which can be recorded on a tape. The present invention extends that principle by similarly encoding a digital data stream representing a television picture in a similar way.

The multilevel code may comprise a signal having more than two amplitude levels. As an alternative or in addition the multilevel signal may comprise a plurality of phase values or a combination of the two to enable more bits to be encoded in each data period.

The multilevel code may have four levels giving a data rate of half the data rate of the received digital data stream. This will enable an input digital television signal of 5Mbits/s to be recorded using standard VHS video recorder components.

The invention further provides a method of replaying a television signal in the form of a digital data stream from a record carrier using replay apparatus having a bandwidth of less than the data rate of the digital data stream, the digital data stream being recorded on the record carrier by means of a multilevel code at a data rate which is lower than the data rate of the television signal, the method comprising the steps of

- reading the multilevel code from the record carrier,
- converting the multilevel code to a digital data stream at the data rate of the television signal, and
- applying the digital data stream to an output.

Thus if a digital television signal is recorded on a tape either off air or as a pre-recorded tape in the form of a multilevel code the data rate of a decoded bit stream can be greater than that capable of being supported by the replay apparatus. In this way a VHS video recorder can be made capable of replaying a digital television signal having a data rate of 5Mbits/s or greater depending on the number of levels in the multilevel code.

The invention still further provides apparatus for recording a television signal in the form a digital data stream on a magnetic tape, said apparatus having a bandwidth of less than the data rate of the digital data stream, the apparatus comprising means for receiving the digital data stream, means for encoding the received digital data stream into a multilevel code at a data rate which is less than the data rate of the received digital data stream and means for recording the multilevel code on the record carrier.

Thus apparatus such as a VHS video recorder can be arranged to record digital television signals whose data rate is greater than the channel bandwidth of the video recorder by providing an encoder which takes the input data stream and converts it to a lower rate data stream by encoding a plurality of bits into a single data period using a multilevel code. Once data has been converted the multilevel code is recorded on the tape in the same way as normal analogue television signals.

The means for encoding the digital data stream may comprise means for applying the received digital data stream to an encoder in n-bit packets, where n is greater than one, means for converting each n-bit packet into a multilevel code having at least one level for each n-bit combination, and means for feeding the multibit code to the record head of the recorder at a data rate of 1/n times the data rate of the received digital data stream.

Thus the encoding means is of substantially the same form as that disclosed in our co-pending UK patent application No. 9605614.8 (PHB 34056) which uses a multilevel code for recording teletext data using a VHS video recorder. A four level code (n=2) will allow a reduction in the data rate by two while an eight level code (n=3) will allow a reduction in the data rate by three.

The invention still further provides apparatus for replaying a television signal in the form of a digital data stream from a magnetic tape, the digital data stream being encoded by means of a multilevel code at a data rate less than that of the digital data stream, the apparatus comprising means for feeding the multilevel code signal to a decoder which is arranged to convert the multilevel code to a binary code at the data rate of the digital data stream and means for feeding the binary code to a television receiver for display.

The multilevel code may be a four level code, the decoder producing two bits from each four level code.

Thus a digital television signal recorded "off-air" or produced as a prerecorded tape using a multilevel code for recording the digital data stream may be replayed by a VHS video recorder which is provided with the appropriate decoding means to enable the digital data stream to be reconstituted from the multilevel code read from the tape.

The decoder may include an equaliser which may be a decision feedback equaliser. The provision of such an equaliser improves the decoder performance particularly in the presence of noise. Such provision becomes increasingly important as the number of levels of the multilevel code are increased as this imposes greater performance requirements on the decoder.

The invention yet further provides a VHS video recorder including selection means for selecting for recording either an analogue television signal or a digital television signal, means for encoding the digital television signal into a multilevel signal at a data rate lower than the data rate of the received digital television signal, and means for recording the multilevel signal on a tape.

By this means a video recorder can be provided which will record analogue television broadcasts and digital television broadcasts without requiring any modification to the recording or replay mechanisms. Both analogue television signals and digital television signals can be recorded using the same record and replay heads and without requiring any changes in drum speed. Consequently inexpensive mechanisms can be used, any changes from the standard VHS recorders being confined to selection of sources and encoding and decoding of digital signals which can all be performed using integrated circuitry.

The recorder may include a further encoder for encoding the analogue television signal into a further digital television signal, the selection means being arranged to select either the digital television signal or the further digital television signal for application to the first mentioned encoding means.

The recorder may include further selection means for directing an analogue television signal replayed from the tape to an analogue output and

for directing a multilevel signal replayed from the tape to a multilevel decoder for converting the multilevel signal to a digital television signal.

Such a recorder has the advantage that it can be used to record both digital and analogue television signals and to replay an analogue recorded tape to an analogue output and a digitally recorded tape to a digital output.

The recorder may include a further encoder for encoding the analogue television signal into a further digital television signal, the selection means being arranged to select either the digital television signal or the further digital television signal for application to the first mentioned encoding means.

MPEG 1 and MPEG 2 encoders can encode an analogue television signal into a digital television signal at data rates between 1.5 Mbits/s and 10 Mbits/s. MPEG 2 encoded television signals can have a higher quality than normal VHS analogue video with data rates in the region of 5 Mbits/s and consequently if an input analogue signal is passed through an MPEG 2 encoder and then recorded using the multilevel encoder a higher quality recording is possible.

The video recorder may include a multilevel decoder for decoding the multilevel code read from the tape and producing a digital television data stream, a digital decoder for decoding the digital television data stream and converting it to a standard analogue television signal, and means for feeding the analogue television signal to an output.

Such a recorder can take an analogue television signal and convert it to a digital signal for recording and then on replay reconvert the digital signal replayed from the tape into a standard analogue television signal. Thus if the analogue television signal is encoded according to the MPEG 2 standard a higher quality output is obtained than with normal analogue recording on a VHS recorder.

The above and other features and advantages of the invention will be apparent from the following description, by way of example, of embodiment of the invention with reference to the accompanying drawings, in which:-

Figure 1 shows a digital television signal in the form of a standard

broadcast teletext signal and the effect the restricted bandwidth of a VHS recorder on this signal,

Figure 2 shows a low level code representing the broadcast teletext signal which is suitable for recording on or replay from a VHS recorder,

Figure 3 shows on an enlarged timescale a portion of the signal shown in Figure 2,

Figure 4 shows in block schematic form a first embodiment of apparatus according to the invention,

Figure 5 shows in block schematic form a second embodiment of apparatus according to the invention, and

Figure 6 shows in block schematic form a third embodiment of apparatus according to the invention.

Figures 1 and 2 show digital television signals in the form of teletext data signals and illustrate the coding method used in our co-pending UK Patent Application No. 9605664.8 (PHB 34056) to enable teletext data to be recorded on and replayed from a tape using a VHS VCR.

Figure 1 shows a standard broadcast teletext signal as received by a receiver. The data rate of the teletext signal is greater than 5MHz and consequently such a signal will be distorted when it is fed through a standard VHS video recorder which has a channel bandwidth of around 3MHz. Figure 1 (b) shows how the teletext signal is affected by the channel bandwidth of a VHS recorder. As can be seen the initial clock run-in information is lost and on replay such a signal would not be decodable by standard teletext decoder.

In order to overcome this problem a multilevel code which can have a data rate which is lower than that of the standard teletext data rate is utilised.

Figure 2 shows a line of teletext data encoded according to a four amplitude level code. The initial clock run-in has been replaced by a lower frequency clock run-in while the framing code and data are replaced by the four level code. The four levels in this instance are four amplitude levels and consequently in each data period two bits can be encoded the four levels giving the codes 00, 01, 10, and 11. As a result the teletext signal re-encoded

according to the multilevel code now has a data rate which falls within the bandwidth of the VHS recorder.

It has been recognised that a similar encoding of digital television signals having data rates of up to approximately 5 Mbits/s could be performed and that this would enable these digital television signals to be recorded and replayed using a VHS VCR provided with appropriate encoding and decoding circuits. This is on the assumption that a four level code is used. An eight or sixteen level code, or an even greater number of levels, would enable higher bit rate television signals to be recorded but would impose higher performance requirements on the encoding and decoding circuits.

With digital television signals there may not be a clock run in and framing code on each line and consequently it would be necessary to pass all the incoming data through the buffer memory and encoder and to record it all on the tape. On replay it would then not be necessary to add the clock run in and framing code to the data read from the tape. These, however, would be the only significant differences in recording a digital television signal from recording teletext signals, which are of course digital signals multiplexed with an analogue television signal and which may also be multiplexed with a digital television signal.

Figure 4 shows in block schematic form a VHS video recorder which is capable of recording and replaying both digital and analogue television signals. As shown in Figure 4 the dotted box 1 includes those items which are additional to or modifications of the standard components of a VHS video recorder and which enable digital television signals to be recorded. As shown in Figure 1 the recorder has an aerial input 2 which is connected to the normal tuning circuits 3, intermediate frequency stages 4, and demodulator 5, the output of which is the standard CVBS signal. The output of the demodulator 5 is fed to an input 6 of a selector circuit 7, whose output is fed to the usual luminance, chrominance, and audio signal processor 8 of a VHS recorder. The processor 8 has connections to and from the record and replay heads 9. Conveniently a remote control handset 10 intercommunicates with a remote

control receiver 11 to enable instructions from the user to be made to the video recorder in known manner. These user instructions will be for example to set the recorder into a condition to record a received signal; either an analogue signal in which case the selected channel for from the tuner 3 will be controlled from the remote control handset 10 or a digital television signal in which case the input 15 and output 16 interfaces will become operable. In addition the selector 7 will be arranged to select either the analogue input at is input 6 or a digital television signal input at a second input 12. This is under the control of a control and timing circuit 13 which receives the instructions from the remote control handset via the remote control receiver 11. The control and timing circuit 13 will, in addition to the normal control and timing functions of such a circuit in a VHS recorder, also control the recording of digital video signals as will be described hereinafter.

The conventional functions of a VHS VCR are described only in outline here as these are not relevant to the invention. As shown in Figure 4 the recorder has a further input 14 to which in operation a digital television signal is applied. This digital television signal will be derived from either a set top box or a digital television receiver and will be received over a standard digital interface such as for example the IEEE 1394. This digital data stream is fed via an input interface 15 to a buffer store and error correction circuit 16 under the control of the control and timing circuit 13. The output of the buffer store 16 is fed to a tape encoder 17. The tape encoder 17 takes the stored data stream which may typically have a data rate of 5 Mbits/s and convert if into a multilevel code having a lower data rate for example 2.5 Mbits/s. The tape encoder is as described in our co-pending application No. 9605614.8 (PHB 34056). This encoder will produce a multi level code which combines a plurality of bits for each date period. In this way a lower data rate is achieved bringing it within the bandwidth of a standard VHS VCR at the expense of increased complexity in encoding and decoding the digital data. In the specific embodiment described in our co-pending application four amplitude levels are used enabling two bits to be encoded in each data period, thus halving the

required data rate. As further described in our co-pending application a larger number of amplitude levels and/or phase values may be used enabling more bits to be encoded in each data period. Consequently an even lower data rate or a higher input bit rate may be recorded. Thus when the user selects the digital video to be recorded the selector 7 takes the input at its input 12 and feeds this to the processor 8 for recording on the tape.

Thus as described, Figure 4 shows a VHS video recorder including selection means 7 for selecting for recording either an analogue television signal or a digital television signal. It includes means for encoding the digital television signal into a multilevel signal at a data rate lower than the data rate of the received digital television signal, that is the tape encoder 17. This multilevel signal is then passed through the selector 7 to the processor 8 and from there to the record head 9 to effect recording of the multilevel code on the tape.

In order to replay a digital television signal recorded on the tape the user selects the replay function by means of the remote control handset 10 and a further selector 18 is arranged to feed the signal at its input to a tape decoder 19. The tape decoder 19 performs the inverse function to the tape encoder 17 and its output is fed to the buffer memory and error corrector 16 under the control of the control and timing circuit 13. The output of the buffer memory 16 is then in the same form as that received at the input 14 for recording or if a precorded tape is replayed which is encoded using the multilevel code a standard digital format is available for display using either a set top box or a television set including a digital decoding circuit. This output is fed via an output interface 20 to an output 21 at which the digital television signal is available. If it is desired to replay an analogue television signal the selector 18 is set , under the control of the control and timing circuit 13, so that its input is fed to a second output 22. The second output 22 is either connected to a SCART output 23 as a standard CVBS signal or via a modulator 24 which converts it to a UHF signal to an aerial output 25. Thus as far as analogue recording and replay is concerned, the only additions to the standard VHS video recorder are the first and second selectors 7 and 18 which route the

analogue signal to be recorded and to be replayed in response to instructions entered by the user using the normal remote control unit 10. When a digital television signal is to be recorded or replayed, the first and second selectors are arranged so that the second input of the first selector 7 is selected for recording the signal and the first output of the second selector 18 is selected for replaying the signal. The digital television signal received is encoded by means of an encoder 17 which may take the form of that disclosed in our co-pending application and decoded by the decoder 19 on replay which again may take the form of that disclosed in our co-pending application.

It can be seen that all the mechanical functions of the standard VHS video recorder are retained and consequently a relatively inexpensive mechanism can be used for recording and replaying digital television signals as well as analogue signals.

As an example, if a four level code is used as is described in our co-pending application then a 5 Mbits/s input can be converted to 2.5 Mbits/s for recording on the tape. This will be within the bandwidth of a standard VHS recorder. If instead of a four level code an 8 level code was used then the data rate would be divided by 3. There is of course a trade off between the resolution of the number of levels and the reduced bandwidth required. As stated in our co-pending application as well as amplitude levels the multilevel code could include phase changes or even a combination of the two. Thus with a greater number of levels in the encoder an even higher bit rate could be recorded, but at the cost of increased complexity in the encoder and decoder.

Figure 5 shows an alternative embodiment of a video recorder according to the invention in which television signals received in both analogue and digital form are recorded in digital form on the tape. In Figure 5 those elements corresponding to those in Figure 4 have been given the same reference numerals. In this description of Figure 5 only those aspects which are different from those shown in Figure 4 will be described. The major difference between the arrangement of Figure 5 and that of Figure 4 is that after the demodulator 5 a digital video encoder/decoder 30 is included. An integrated circuit which provides MPEG-2 encoding with less compression than professional equipment

but much more cheaply has been disclosed in a paper by Albert van der Werf, Fons Brüls, Richard Kleihorst, Erwin Waterlander, Math Verstraelen, Thomas Friedrich, entitled "I.McIC: A single-chip MPEG-2 video encoder for storage" published in the Digest of Technical Papers of the 1997 IEEE International Solid-State Circuits Conference. In this way good quality video can be provided with a 5 Mbits/s data rate. Thus an analogue television signal can be fed to the digital video encoder 30 the output of the encoder 30 and passed through the selector 7 to the buffer ram and error correction circuit 16 in the same way as is provided in the embodiment of Figure 4. Digital video signals are again applied via the selector 7 through a digital input/output interface 31. This digital input/output interface 31 is the combination of the two interfaces 15 and 20 of Figure 4. Thus on recording, the major difference between the embodiments of Figures 4 and 5 is that the analogue television signal is converted to a digital signal in the encoder 30 before application to the selector 7. The digitally converted analogue signal is then processed in the same manner as a digital television signal applied to input 14. Thus both analogue and digital television signals are recorded digitally on the tape.

Playback of a tape which has been recorded by this process will follow the same procedure as for the digital television signal shown in Figure 4, except that where a digitally encoded analogue signal has been recorded this signal will be fed from the buffer ram and error correction circuit 16 to the digital video decoder 30 from where it will be applied to the SCART socket 23 or to the modulator 24. Digital video decoders are, of course, well known and will be of the same form as those used in digital set top boxes. In order to retain the ability of the recorder to playback analogue recorded tapes the selector 18 may be retained and under the control of the control circuit 13 will select the analogue output 22 so that a CVBS signal from the processor 8 will be passed from the output 22 to a further selector 31. The selector 31 will, under the control of the control and timing circuit 13, select either the output 22 of selector 18 or the output of the digital video encoder/decoder 30.

With the recorder shown in Figure 5 all recordings are made digitally and the selector 7 is now a digital source selector which selects either the digital

vid ternal encoder 30, that is from an analogue source, or digital
vid xternal source via the bus interface. On playback the digital
vid d by the decoder 30 and converted to a standard analogue
tele and passed to the SCART terminal 23 or to the modulator 24
and ection 25. In addition a digital video output is available via the
inpu erface 31. All recordings are now in the same format and the
vide can be connected to a standard analogue T.V. with no external
digit coder being necessary even when prerecorded digital television
tape ayed. Tapes made on such a machine however cannot be
playe nventional VHS VCR as the recording format is different.

shows a modification of the recorder shown in Figure 5. In this
case al video encoder/decoder uses a different encoding algorithm
which s a lower bit rate, for example MPEG 1 instead MPEG 2. This
may p lower picture quality but a data capacity of for example only 1.5
Mbits/ icient for encoding the television signal according to the MPEG
1 star In this case it is possible to record more than one programme
simulta within the data capacity of the VHS digital recording system
disclos his application. Thus, as shown in Figure 6, three tuners, 3-1 to
3-3, th stages 4-1 to 4-3, and three demodulators, 5-1 to 5-3 are
provide ch of which feeds the digital video encoder decoder 30. One
applica such a facility is when a user would like to record two or more
progra which are transmitted on different channels with the same or
overlap transmission times. Thus a plurality of programmes, for example
three co be recorded simultaneously. On play-back one of the channels
may be ected for replay. As an alternative such an arrangement could be
used to tend the capacity of the tape, that is the tape could record for
example programme three times as long or three times as many programmes
may be recorded on the same length tape. Thus one reduced rate channel
could be recorded, the tape then rewound to the beginning and the process
repeated for channels 2 and 3 on the tape. On play-back the digital video
decoder 30 contains circuitry for identifying the separate data streams, the
desired data stream being chosen by means of instructions from the remote

control handset 10 via the control circuit 13. The chosen data stream is then decoded and passed to the T.V. in analogue form. Alternatively the desired data stream could be selected for transfer to the digital video output bus. In a further alternative all the data streams could be passed to the digital video output bus, the selection of the desired material being made in the external equipment.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design and use of video recording apparatus and component parts thereof and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation of one or more of those features which would be obvious to persons skilled in the art, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of such features during the prosecution of the present application or of any further application derived therefrom.

CLAIMS

1. A method of recording a television signal in the form of a digital data stream on a magnetic tape using a video recorder, the method comprising the steps of;

- receiving the digital data stream
- converting the data to a multilevel code, at a data rate which falls within the bandwidth of the recording apparatus, and
- recording the multilevel code on the tape.

2. A method as claimed in Claim 1 in which the multilevel code comprises a signal having more than two amplitude levels.

3. A method as claimed in Claim 1 or 2 in which the multilevel code has four levels and the data rate is half the data rate of the received digital data stream.

4. A method as claimed in any of Claims 1 to 3 comprising the steps of receiving a plurality of television signals and multiplexing the plurality of television signals to produce the digital data stream.

5. A method as claimed in Claim 4 in which the received television signals are analogue television signals including the step of applying the analogue television signals to an encoder which encodes then into a digital data stream of a given format.

6. A method of replaying a television signal in the form of a digital data stream from a record carrier using replay apparatus having a bandwidth of less than the data rate of the digital data stream, the digital data stream being recorded on the record carrier by means of a multilevel code at a data rate which is lower than the data rate of the television signal, the method comprising the steps of

- reading the multilevel code from the record carrier,
- converting the multilevel code to a digital data stream at the data rate of the television signal, and
- applying the digital data stream to an output.

7. Apparatus for recording a television signal in the form of a digital data stream on a magnetic tape , said apparatus having a bandwidth of less than the data rate of the digital data stream , the apparatus comprising means for receiving the digital data stream, means for encoding the received digital data stream into a multi-level code at a data rate which is less than the data rate of the received digital data stream and means for recording the multilevel code on the record carrier.

8. Apparatus as claimed in Claim 7 in which the means for encoding the digital data stream comprises means for applying the received digital data stream to an encoder in n-bit packets, where n is greater than one, means for converting each n-bit packet into a multilevel code having at least one level for each n-bit combination, and means for feeding the multilevel code to the record head of the recorder at a data rate of 1/n times the data rate of the received digital data stream.

9. Apparatus as claimed in Claim 7 in which n=2.

10. Apparatus as claimed in Claim 7 in which n=3.

11. Apparatus as claimed in any of Claims 7 to 10 in which the multilevel code comprises a plurality of amplitude levels.

12. Apparatus as claimed in any of Claims 7 to 11 including a plurality of tuning circuits each arranged to pass an analogue television signal to a digital encoder, said digital encoder being arranged to separately encode each of the analogue television signals into a corresponding digital television

signal and provide as an output for application to the first encoding means a data stream comprising a multiplexed data stream containing the plurality of digitally encoded analogue television signals.

13. Apparatus for replaying a television signal in the form of a digital data stream from a magnetic tape , the digital data stream being encoded by means of a multilevel code at a data rate less than that of the digital data stream, the apparatus comprising means for feeding the multilevel code signal to a decoder which is arranged to convert the multilevel code to a binary code at the data rate of the digital data stream and means for feeding the binary code to a television receiver for display.

14. Apparatus as claimed in Claim 13 in which the multilevel code is a four level code and the decoder produces two bits from each four level code.

15. Apparatus as claimed in Claim 13 in which the multilevel code is an eight level code and the decoder produces three bits from each eight level code.

16. Apparatus as claimed in any of Claims 13 to 15 in which data from the decoder is written into a buffer RAM.

17. Apparatus as claimed in any of Claims 13 to 16 in which the decoder includes an equaliser.

18. Apparatus as claimed in Claim 17 in which the equaliser is a decision feedback equaliser.

19. Apparatus as claimed in any of Claims 13 to 18 in which the multilevel code comprises a plurality of amplitude levels.

20. Apparatus as claimed in Claim 13 to 19 including a multilevel decoder for decoding the multilevel code read from the tape and producing a digital television data stream, a digital decoder for decoding the digital television data stream and converting it to a standard analogue television signal, and means for feeding the analogue television signal to an output.

21. A VHS video recorder including selection means for selecting for recording either an analogue television signal or a digital television signal, means for encoding the digital television signal into a multilevel signal at a data rate lower than the data rate of the received digital television signal, and means for recording the multilevel signal on a tape.

22. A VHS recorder as claimed in Claim 21 including further selection means for directing an analogue television signal replayed from the tape to an analogue output and for directing a multilevel signal replayed from the tape to a multilevel decoder for converting the multilevel signal to a digital television signal.

23. A VHS recorder as claimed in Claim 21 including a further encoder for encoding the analogue television signal into a further digital television signal, the selection means being arranged to select either the digital television signal or the further digital television signal for application to the first mentioned encoding means.

24. A VHS recorder as claimed in Claim 21 or Claim 23 including a plurality of tuning circuits each arranged to pass an analogue television signal to a digital encoder, said digital encoder being arranged to separately encode each of the analogue television signals into a corresponding digital television signal and provide as an output for application to the first encoding means a data stream comprising a multiplexed data stream containing the plurality of digitally encoded analogue television signals.

25. A VHS video recorder as claimed in Claim 23 or Claim 24 including a multilevel decoder for decoding the multilevel code read from the tape and producing a digital television data stream, a digital decoder for decoding the digital television data stream and converting it to a standard analogue television signal, and means for feeding the analogue television signal to an output.

FIG. 1a

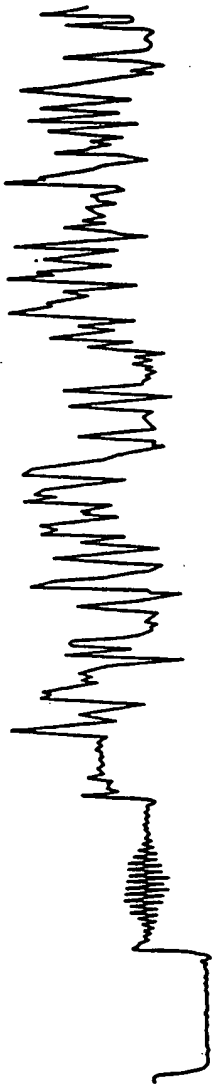

FIG. 1b

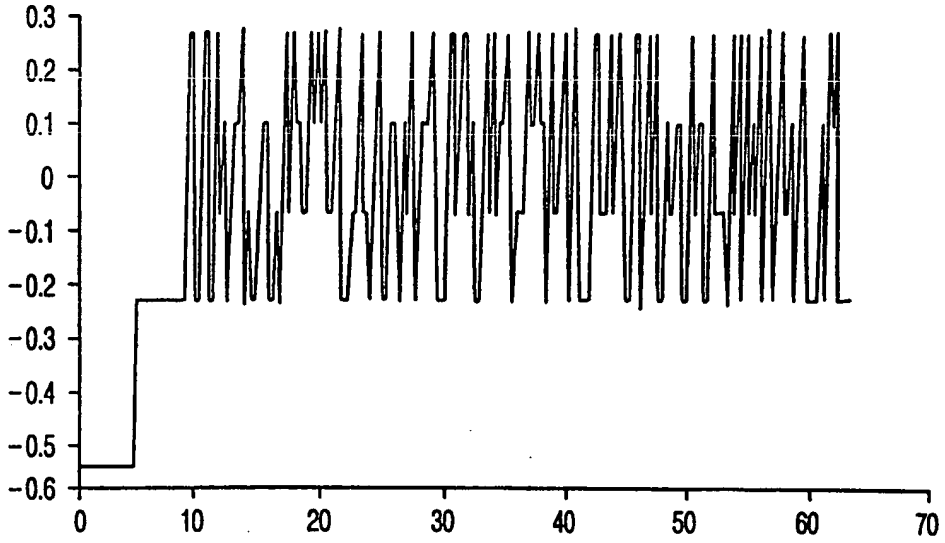
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0
10
20
30
40
50
60
70

FIG. 2

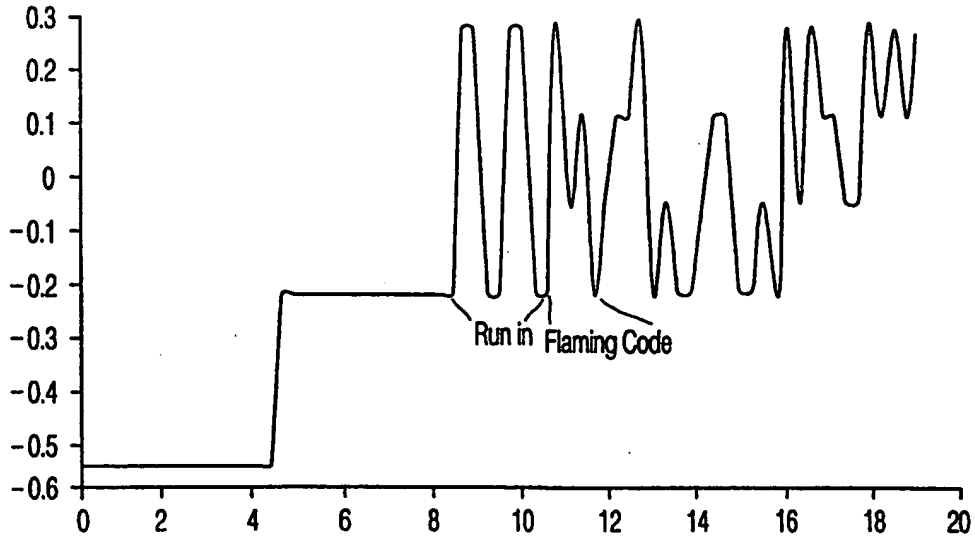
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0
2
4
6
8
10
12
14
16
18
20
Run in
Flaming Code

FIG. 3

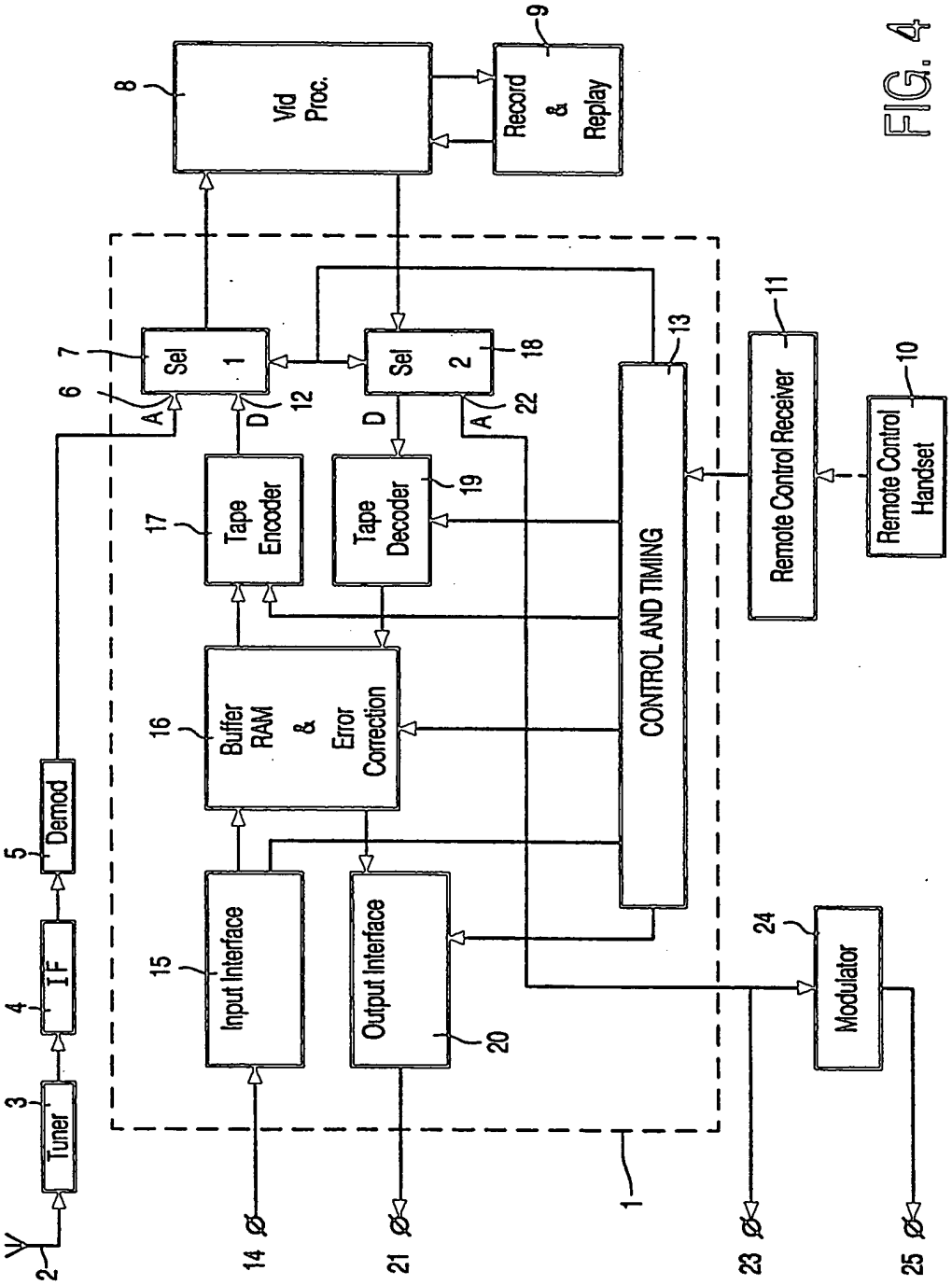
Vid Proc.
8
Record & Replay
9
Sel 1
7
Sel 2
18
A
6
D
12
D
A
22
Tape Encoder
17
Tape Decoder
19
Buffer RAM & Error Correction
16
CONTROL AND TIMING
13
Remote Control Receiver
11
Remote Control Handset
10
Demod
5
IF
4
Tuner
3
Input Interface
15
Output Interface
20
Modulator
24
1
2
14
21
23
25

FIG. 4

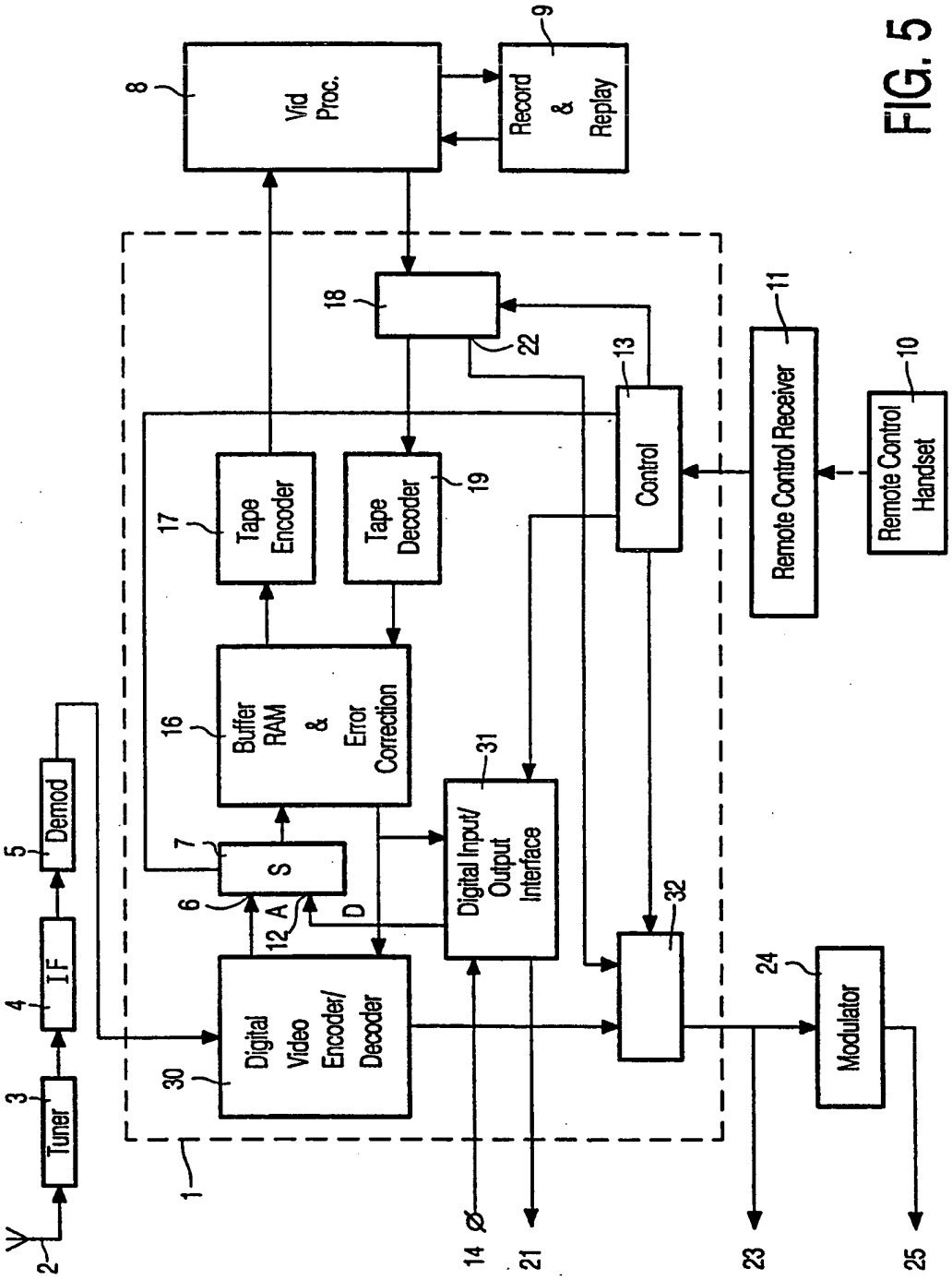
Vid Proc.
8
Record & Replay
9
18
22
13
11
Remote Control Receiver
10
Remote Control Handset
Control
Tape Encoder
17
Tape Decoder
19
Buffer RAM & Error Correction
16
Digital Input/ Output Interface
31
7
S
6
12
A
D
32
Demod
5
IF
4
Tuner
3
Digital Video Encoder/ Decoder
30
24
Modulator
1
2
14
21
23
25

FIG. 5

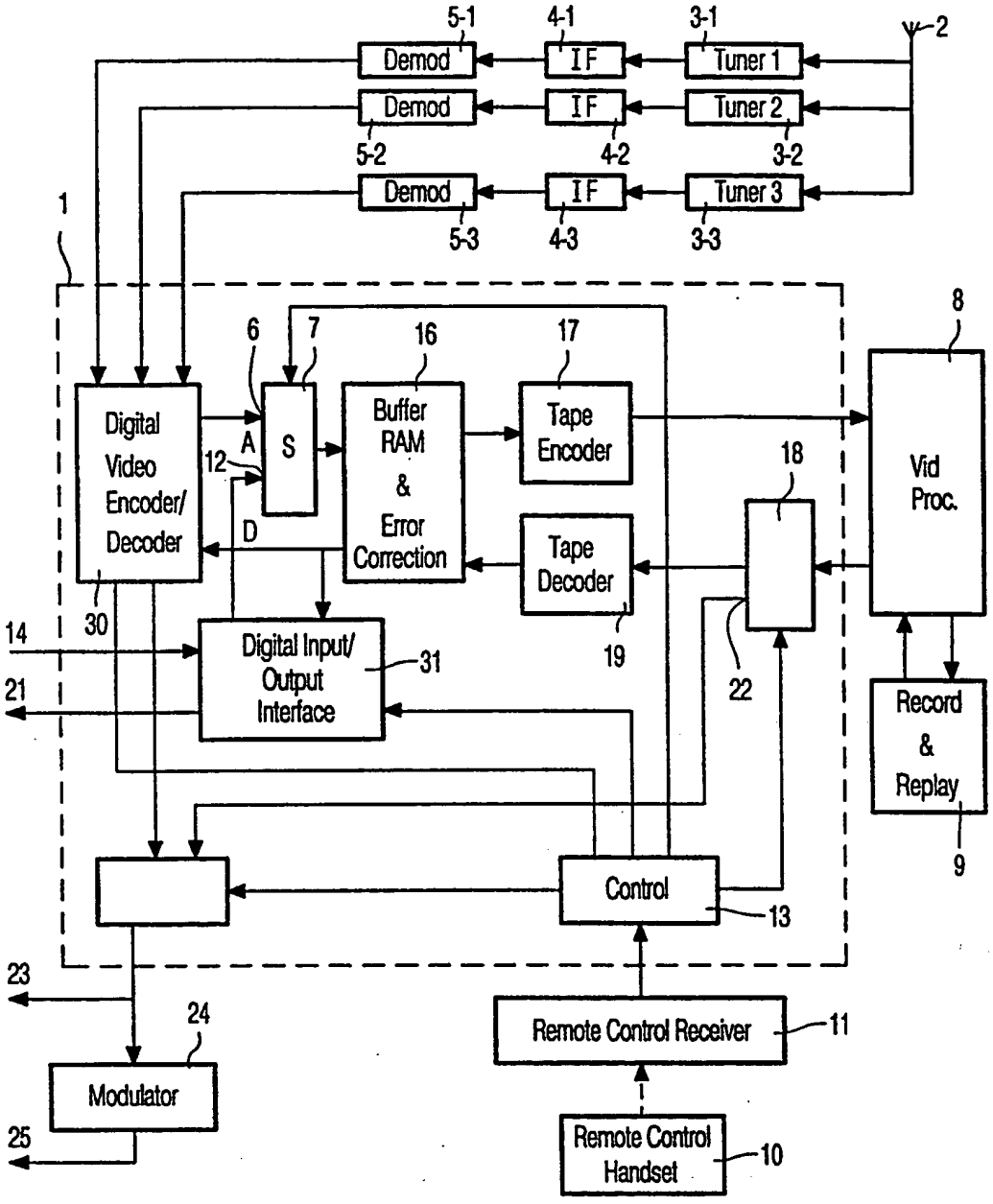
5-1
4-1
3-1
2
Demod
IF
Tuner 1
Demod
IF
Tuner 2
5-2
4-2
3-2
Demod
IF
Tuner 3
1
5-3
4-3
3-3
8
6
7
16
17
Digital Video Encoder/ Decoder
A
S
12
Buffer RAM & Error Correction
Tape Encoder
18
Vid Proc.
D
Tape Decoder
30
14
Digital Input/ Output Interface
31
19
22
21
Record & Replay
9
Control
13
23
24
Remote Control Receiver
11
Modulator
25
Remote Control Handset
10

FIG. 6